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# Consumer Myopia, Competition and the Incentives to Unshroud Add-on Information<sup>\*</sup>

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## Abstract

This paper studies unshrouding decisions in a framework similar to Gabaix and Laibson (2006), but considers an alternative unshrouding mechanism where the impact of advertising add-on information depends on the number of unshrouding firms. We show that shrouding becomes less prevalent as the number of competing firms increases. With unshrouding costs a non-monotonic relationship between the number of firms and unshrouding may arise.

*Keywords:* Bounded rationality; Add-on pricing; Shrouding

*JEL-Classification:* D40; D80; L10

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# 1 Introduction

For the functioning of markets, information and transparency on the consumer side are essential. The degree of consumer information can be heavily influenced by firm strategy, often to the detriment of consumers. One popular business strategy in this respect is to hide information over add-ons with the aim to charge unaware consumers overpriced fees. Prominent examples for this strategy, for instance, include the pricing of printer and corresponding cartridges or the pricing of current accounts and overdraft fees as add-on.<sup>1,2</sup>

In a recent paper, Gabaix and Laibson (2006), henceforth GL, analyze firms' incentives to shroud such add-on information in a competitive environment. They show that if the number of myopic consumers, who do not foresee high add-on prices or underestimate add-on consumption, are sufficiently high, an equilibrium with high add-on fees and shrouding of add-on information exists. Base good prices, however, are low as firms want to attract many consumers who buy the overpriced add-on. In this equilibrium, consumers who are aware of this pricing strategy (sophisticated consumers in the terminology of GL) substitute away from add-on consumption. In GL, the existence of such a shrouding equilibrium is independent of the number of firms competing in a market, leading to the conclusion that intensifying competition does not improve information on the consumer side.

In GL, unshrouding of add-on information has two effects. Firstly, sophisticated consumers can now observe the add-on price. Secondly, if at least one firm decides to unshroud a fraction of myopic consumers is educated and becomes aware of the add-on. In this paper, we propose an alternative unshrouding mechanism where the number of myopic consumers who become educated by unshrouding increases with the number of unshrouding firms. The reason for this modification is that it is more likely that a myopic consumer picks up that information and becomes aware of the add-on if more firms send out advertising messages.

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<sup>1</sup>In practice, consumers might often be informed about the (high) prices of printer cartridges, but might underestimate their importance and, hence, underestimate the total costs of buying a certain printer. In this context, an unshrouding strategy by a firm might include the disclosure of the total cost of printing, for example, by providing typical consumer examples.

<sup>2</sup>See Armstrong and Vickers (2012) for a discussion of such strategies in the retail banking industry.

We characterize the equilibrium of the shrouding game and provide two arguments why in markets with many competitors shrouding of information may be less prevalent. Firstly, unshrouding equilibria exist for a wider range of parameter values if the number of competing firms increases. The reason is that, in our setup, a strategic complementarity in unshrouding incentives arises (Bulow et al., 1985). The more firms unshroud add-on information, the larger are the incentives for other firms to unshroud as well as less myopic consumers, who can be fooled by high add-on prices, remain in the market. This result is in contrast to GL. Secondly, as in GL, under a wide range of parameters multiple equilibria exist (all firms shrouding and all firms unshrouding). Thus, equilibrium selection is an issue. As the number of firms increases, unshrouding equilibria become more favorable in terms of risk considerations making it more likely that firms coordinate on the unshrouding equilibrium. In particular, we show that the parameter range, where the unshrouding equilibrium is picked according to risk dominance (Harsanyi and Selten, 1988) and to global games (Carlsson and van Damme, 1993), becomes larger as competition intensifies. Given these two reasons, this paper therefore argues that shrouding of add-on information may be less likely to be observed in competitive markets, and fostering market entry may be an effective tool to raise market transparency and consumer information.

The paper is also related to recent work by Heidhues et al. (2012) who analyze a model with perfect substitutes where firms may shroud one price component (instead of an add-on). The authors demonstrate that shrouding does only take place in concentrated markets. However, with positive unshrouding costs an unshrouding equilibrium ceases to exist. We also show that intensified competition decreases incentives to shroud, however, in contrast, in our framework an unshrouding equilibrium can also exist in the presence of unshrouding costs.

More generally, the paper is related to the literature that analyzes competition in the presence of behaviorally biased consumers and on firm strategy how to exploit such imperfect behavior.<sup>3</sup> For instance, Spiegel (2006) considers a model where complicated products have multiple price elements which all need to be evaluated to infer a product's total price, but consumers only

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<sup>3</sup>A survey on the impact of competition in markets where consumers exhibit behavioral biases is provided by Huck and Zhou (2011) and a textbook treatment is provided by Spiegel (2011).

base their purchase decision on one single element. Piccione and Spiegler (2012) and Chioveanu and Zhou (2013) develop models where consumer can be confused by different price frames. Carlin (2009) and Gu and Wenzel (2013) study firm's incentives to use obfuscation strategies to impede consumers' ability to compare different offers.

## 2 The model

The model is based on Gabaix and Laibson (2006), but differs in the effect of unshrouding. In contrast to GL, the share of myopic consumers who becomes educated due to unshrouding depends on the number of unshrouding firms.

We consider an oligopoly market where  $n \geq 2$  firms offer a base good and an add-on. Each consumer demands at most one unit of the base good and one unit of the add-on where the add-on can only be purchased from the firm where the base good has been bought. All firms produce the base good and the add-on at no costs.

Base good prices,  $p_i$ , are observable by all consumers. Add-on prices,  $\hat{p}_i$ , however, can only be observed if firms advertise them. There are two types of consumers: myopic and sophisticated consumers. Sophisticated consumers are aware of the add-on and form beliefs about add-on prices if they are shrouded. Myopic consumers are completely unaware of the add-on and, hence, base their purchase decision solely on base-good prices.<sup>4</sup> Initially, the share of myopic (sophisticated) consumers is  $\alpha$  ( $1 - \alpha$ ), where  $\alpha \in (0, 1)$ .

Firms can unshroud add-on information, that is, advertise their add-on fees. Unshrouding has two consequences. Firstly, if a firm decides to unshroud, sophisticated consumers learn the add-on price charged by this firm. Secondly, by unshrouding some myopic consumers become aware of the add-on and behave like sophisticated consumers. In contrast to GL, we assume that the fraction of consumers that becomes sophisticated depends on the number of unshrouding firms. Define  $\mu(k)$  as the share of myopic consumers who remain myopic if  $k$  firms decide to unshroud. We assume that  $\mu(k)$  is a decreasing

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<sup>4</sup>Kosfeld and Schüwer (2011) analyze a variant of GL where firms can (imperfectly) discriminate between sophisticated and myopic consumer.

function of the number of unshrouding firms,  $\frac{\partial \mu(k)}{\partial k} < 0$ . Conversely, if  $k$  firms unshroud, a fraction  $(1 - \mu(k))$  of myopic consumers becomes sophisticated.

There are several reasons why a larger number of unshrouding firms increases the number of sophisticated consumers. Firstly, if unshrouding firms send out advertising messages randomly to consumers it is more likely that a consumer receives an advertising message if more firms advertise. Secondly and alternatively, suppose that not all myopic consumers pay attention to add-on prices even if they receive disclosure information. For instance, this could be because some consumers do not understand that they will want to buy the add-on in the future. However, if consumers receive multiple warnings and repeatedly receive information on high add-on fees there might be a larger likelihood that they pick up this information eventually and behave accordingly. With both interpretations, we would argue that the number of consumers becoming informed increases in the number of unshrouding firms. In Section 4 we provide a simple microfoundation based on advertising that derives a function  $\mu(k)$ .

Firms can charge a maximal price of  $\bar{p}$  for the add-on. Sophisticated consumers can avoid buying the add-on by turning to an outside substitution at a cost  $e$ . As in GL, sophisticated consumers decide whether to avoid the add-on at the same stage where they decide on the base-good purchase.

To model competition in the base-good market we follow GL. Define  $x_i$  as the anticipated net surplus of buying the base good from firm  $i$  relative to the net surplus from buying the next best alternative. As we solve for symmetric equilibria, the next best alternative is the symmetric equilibrium price charged by all other firms. Equilibrium prices are denoted by an asterisk.

The anticipated net surplus for sophisticated consumers equals

$$x_i = [p^* + \min(e, E\hat{p}^*)] - [p_i + \min(e, E\hat{p}_i)], \quad (1)$$

where  $E\hat{p}_i$  and  $E\hat{p}^*$  are the expected add-on prices.

For myopic consumers, ignoring add-on purchases, the anticipated net surplus is

$$x_i = p^* - p_i. \quad (2)$$

The probability that a consumer chooses to buy the base good from firm  $i$

is denoted by  $D(x_i)$  which depends on the anticipated net surplus from this alternative. This demand function strictly increases with  $x_i$  and is bounded between zero and one.<sup>5</sup>

We study the following three-stage game:

- In stage 1, firms set prices for the base good,  $p_i$ , as well as for the add-on  $\hat{p}_i$ . In addition, each firm decides whether to unshroud add-on information.
- In stage 2, consumers decide from which firm to buy the base good. Sophisticated consumers (and myopic consumers who have become sophisticated) can also decide whether to substitute away from the add-on.
- In stage 3, myopic consumers buy the add-on. Sophisticated consumers buy the add-on only if they have not substituted away at stage 2.

### 3 Results

This section provides the equilibrium of the game. The following Proposition states equilibrium shrouding decisions:

**Proposition 1.** Let  $\underline{\alpha} = \frac{e}{\bar{p}}$  and  $\bar{\alpha} = \frac{e}{\bar{p}\mu(n-1)}$ , where  $\underline{\alpha} < \bar{\alpha}$ .

- i) If  $\alpha \geq \underline{\alpha}$ , there exists a shrouding equilibrium where all firms shroud add-on information. Firms choose an add-on price  $\hat{p}^* = \bar{p}$  and all sophisticated consumers substitute away from add-on consumption.
- ii) If  $\alpha \leq \bar{\alpha}$ , there exists an unshrouding equilibrium where all firms unshroud add-on information. Firms choose an add-on price  $\hat{p}^* = e$  and all sophisticated consumers decide to purchase the add-on.

*Proof:* see the Appendix.

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<sup>5</sup>Formally, such a demand function can be derived by a random-utility model (e.g., Anderson et al., 1992).

The firms' shrouding decisions depend on the number of myopic consumers in the market. A shrouding equilibrium exists if the share of myopic consumers is larger than some critical number,  $\underline{\alpha}$ . Conversely, an unshrouding equilibrium exists if the number of myopic consumers is sufficiently low,  $\alpha \leq \bar{\alpha} = \frac{e}{\bar{p}\mu(n-1)}$ . Note that, as in GL, for some parameters ranges, multiple equilibria exist. For  $\alpha \in [\underline{\alpha}, \bar{\alpha}]$ , both a shrouding and an unshrouding equilibrium exist. Shrouding is the unique symmetric equilibrium if  $\alpha > \bar{\alpha}$ , and unshrouding is the unique symmetric equilibrium if  $\alpha < \underline{\alpha}$ .

In GL, the conditions for a shrouding or an unshrouding equilibrium to exist, are independent of the number of competitors ( $n$ ). That is, according to GL, whether or not we should observe shrouding of add-on information is independent of the competitive pressure in an industry. This can best be seen by noting that in GL  $\mu(k) = \mu$  is a constant and does not depend on the number of unshrouding firms.<sup>6</sup> This is in contrast to our model.

In the following, we will argue that, in our setup, shrouding becomes less prevalent if competition becomes more intense. We provide two arguments for this claim. First, we will show that as the number of firms increases the parameter range for which an unshrouding equilibrium exists increases. Secondly, we show that the unshrouding equilibrium becomes more favorable in terms of risk consideration with a larger number of firms. This is relevant as the range where multiple equilibria exist becomes larger with more firms.

An unshrouding equilibrium exists if  $\alpha < \bar{\alpha} = \frac{e}{\bar{p}\mu(n-1)}$ . It can be easily seen that this parameter range increases with the number of firms in the market:

$$\frac{\partial \bar{\alpha}}{\partial n} = -\frac{e}{\bar{p}[\mu(n-1)]^2} \frac{\partial \mu}{\partial n} > 0. \quad (3)$$

**Proposition 2.** As the number of firms increases, the parameter range, for which an unshrouding equilibrium exists, increases.

Proposition 2 shows that the existence of an unshrouding equilibrium depends on the intensity of competition. The reason for this result is a strategic complementarity (in the sense of Bulow et al. (1985)) in unshrouding incen-

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<sup>6</sup>In GL, the corresponding cut-off values are  $\underline{\alpha} = \frac{e}{\bar{p}}$  and  $\bar{\alpha} = \frac{e}{\bar{p}\mu}$ . Both values are independent of the number of firms,  $n$ .



tives. For given (base good and add-on) prices, each unshrouding firm reduces the number of myopic consumers and, hence, increases the incentives to unshroud for other firms as well. This is simply because the number of myopic consumers who would buy the expensive (shrouded) add-on becomes smaller with more unshrouding competitors. In consequence, unshrouding is more likely to be an equilibrium if the number of competitors is large, even if the initial number of myopic consumers is high.

In Heidhues et al. (2012) a larger number of firms also makes unshrouding more likely. The mechanism underlying their result differs however. In their model with a potentially shrouded price component, an unshrouding firm can attract additional consumers from competitors by adopting a transparent price strategy, and such a strategy is only worthwhile if competition is sufficiently intense.

Note, however, that as the number of firms increases, the parameter range with multiple equilibria also becomes larger, that is, the interval  $[\underline{\alpha}, \bar{\alpha}]$  becomes larger.<sup>7</sup> Hence, equilibrium selection is an issue. In our case, for any given base good price, unshrouding is a relatively safe strategy yielding a safe payoff of  $e$  for every attracted customer. There is risk associated with the shrouding strategy. The payoff for selling the add-on decreases in the number of unshrouding firms. If few firms unshroud a high payoff from add-on sales can be expected, however, the payoff is low if many firms decide to unshroud as the number of myopic consumers would be small in that case.

To select among equilibria, we use the notion of risk dominance by Harsanyi and Selten (1988) and the selection criterion based on a global games approach offered by Carlsson and van Damme (1993). Both criteria take risk considerations into account and deliver similar results.<sup>8</sup> A good argument for selecting equilibria in terms of risk is also given in laboratory experiments. Among others, van Huyck et al. (1990) and Schmidt et al. (2003) show that in coordination games risk dominated equilibria are more likely to be chosen by actual players.

We find:

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<sup>7</sup>As shown above the upper bound increases with  $n$  and the lower bound is independent of  $n$ .

<sup>8</sup>In the case of two players, both criteria coincide, but deviate for a larger number of players. However, qualitatively similar results arise when applying either of these criteria (Kim, 1996).

**Proposition 3.** As the number of firms increases, the parameter range, where the unshrouding equilibrium is the selected equilibrium according to risk-dominance and according to global games, increases.

*Proof:* see the Appendix.

Propositions 2 and 3 provide two arguments why unshrouding of add-on information becomes more prevalent as the intensity of competition increases: Unshrouding becomes an equilibrium for a larger parameter range and, in case of multiple equilibria, the unshrouding equilibrium becomes more favorable in terms of risk. This is intuitively appealing as, with many firms, it is more likely that at least some firms unshroud making it more risky to shroud the add-on. In consequence, the riskless unshrouding option becomes more attractive. The policy implication we can draw from this is that fostering entry of more firms can have, besides the positive competitive effect on base good competition,<sup>9</sup> the beneficial effect of promoting market transparency by increasing firms' incentives to educate consumers.

## 4 Example

The analysis so far has only assumed that  $\mu(k)$  is decreasing in the number of unshrouding firms. This section considers a simple microfoundation based on advertising that derives such a function.

### Example 1

Suppose that each unshrouding firm sends out an advertising message which is received and understood by a myopic consumer with probability  $\lambda \in (0, 1)$ .<sup>10</sup> Assuming that messages are independent from each other, then if  $k$  firms decide to unshroud and send out an advertising message, a fraction  $(1 - \lambda)^k$  of myopic consumers do not pick up that information and remains myopic while a fraction  $1 - (1 - \lambda)^k$  receives and understands the disclosure information. Then,  $\mu(k) = (1 - \lambda)^k$  and  $\frac{\partial \mu(k)}{\partial k} = (1 - \lambda)^k \ln(1 - \lambda) < 0$ .

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<sup>9</sup>See GL, for a discussion on this issue.

<sup>10</sup>For costly advertising we refer to the discussion in Section 5.

As  $\frac{\partial \mu(k)}{\partial k} < 0$  our results from Propositions 2 and 3 immediately apply and, as the number of firms is increased, the parameter range with an unshrouding equilibrium increases. Interestingly, in this example, it can also be shown that, if the number of firms becomes sufficiently large,  $\bar{\alpha}$  eventually becomes larger than one, and unshrouding is an equilibrium for all  $\alpha \in (0, 1]$ . This critical number of competing firms can be calculated explicitly:

$$n > 1 + \frac{\ln \left[ \frac{e}{p} \right]}{\ln[1 - \lambda]}. \quad (4)$$

Hence, if competition is sufficiently intense, unshrouding is always an equilibrium, independent of the initial level of consumer myopia (as measured by  $\alpha$ ).

## Example 2

In example 1, it is assumed that the probability that a myopic consumer receives any given advertising message is independent of the number of firms in the market. As a consequence, if all firms in the market decide to unshroud, the number of consumers who become aware of add-ons is higher in larger markets. In this section, we consider an example where the probability that a consumer receives a given advertising message depends on the number of firms. In other words, the impact of advertising is related to a firm's market share.

Suppose that a myopic consumer receives an advertising message with a probability of  $1 - (1 - \lambda)^{\frac{1}{n}}$ . Hence, in large markets (high  $n$ ) a given advertising message has a smaller effect. Then, the share of myopic consumers who do not receive any message if  $k$  firms choose to advertise add-on information is  $\mu(k) = (1 - \lambda)^{\left(\frac{k}{n}\right)}$ .<sup>11</sup> As  $\frac{\partial \mu(k)}{\partial k} = \frac{1}{n}(1 - \lambda)^{\frac{k}{n}} \ln(1 - \lambda) < 0$ , the results from Propositions 2 and 3 apply.

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<sup>11</sup>Note that, with this formulation, if all firms decide to unshroud the number of consumers who become aware of add-ons is independent of the number of competing firms. That is,  $\mu(k = n) = (1 - \lambda)$ .

## 5 Costly unshrouding

So far, unshrouding add-on information has been costless. Now suppose there is a (fixed) cost  $c > 0$  associated with unshrouding. In general, incentives to unshroud will be lower with unshrouding costs.

Notice first that, with perfect competition (base products and add-ons are homogenous products), unshrouding equilibria cannot exist because the average profit level per consumer is competed down toward marginal cost (zero, in our case) and firms would earn negative profits if unshrouding would take place. This is the case analyzed in Heidhues et al. (2012). However, if firms have market power, unshrouding equilibria may still exist, though under more restrictive conditions than in the base case.

As the incentives to shroud/unshroud are difficult to analyze with general demand functions we now use the circular city approach to model differentiated base goods where the degree of product differentiation / market power is denoted by the transport cost parameter  $t$  (Salop, 1979).<sup>12</sup> An unshrouding equilibrium exists under the following conditions:

**Proposition 4.** Define  $\hat{\alpha} = \frac{ne+2\sqrt{t(t-cn^2)}-2t}{n\bar{p}\mu(n-1)}$ . Then, a symmetric unshrouding equilibrium exists if

- i)  $\alpha \leq \hat{\alpha}$ ,
- ii)  $\frac{t}{n^2} \geq c$ .

*Proof:* see the Appendix.

The first condition states that for an unshrouding equilibrium to exist, the share of myopic consumers must not be too large. The second condition states unshrouding costs must not be too high to ensure non-negative profits in an unshrouding equilibrium. Note that, for  $c = 0$ , condition i) simplifies to  $\hat{\alpha} = \frac{e}{\bar{p}\mu(n-1)} = \bar{\alpha}$ , the condition from the base model without unshrouding costs (see Proposition 1). Condition 2 is always fulfilled with  $c = 0$ .

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<sup>12</sup>Qualitatively similar results are obtained in the case of a random-utility model as in Anderson et al. (1992), however the analysis is less tractable.

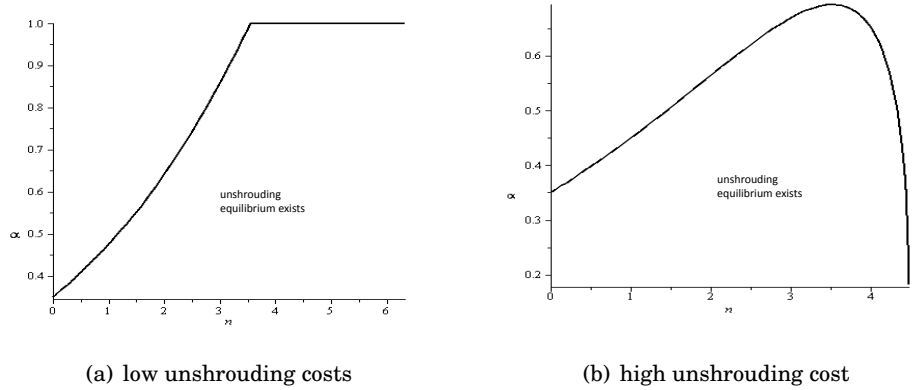


Figure 1: Existence of unshrouding equilibrium

We now analyze the impact of the number of firms on the existence of an unshrouding equilibrium. Suppose unshrouding costs are not too high such that condition ii) is met. Then, increasing the number of firms has two effects. First, as in the base model without unshrouding costs, shrouding becomes a less attractive option if many other firms have unshrouded so that the number of remaining myopic consumers is small. This is because  $\mu(k)$  decreases with  $k$ . Second, as with positive  $c > 0$ , unshrouding profits become rather low if there are many firms and the incentives to deviate from unshrouding to avoid paying  $c$  rises with the number of firms. This can be seen by noting that  $\frac{\partial \hat{\alpha}}{\partial n} |_{\mu=const.} < 0$ . The overall impact of the number of firms depends on the strength of those two effects and, in particular, on the level of the unshrouding cost. We illustrate this by using  $\mu(k) = (1 - \lambda)^k$  from example 1 and using parameter values  $\bar{p} = 1, e = 0.5, \lambda = 0.3, t = 1$  and two levels of unshrouding costs: low unshrouding cost ( $c = 0.025$ ) and high unshrouding cost ( $c = 0.05$ ).<sup>13</sup> The results are displayed in Figure 1. The left panel shows that, with low unshrouding costs, the result from the base model is confirmed. The existence of an unshrouding equilibrium is more likely with more firms. With high unshrouding costs, the impact of competition is non-monotonic: If the number of firms is increased in a concentrated market the scope for an unshrouding equilibrium rises while increasing the number of firms in an already unconcentrated market leads to a smaller parameter range for which an unshrouding equilibrium exists.

To sum up, the incentives to unshroud are lower with unshrouding costs.

<sup>13</sup>We find qualitatively similar results for other parameter values.

However, unshrouding equilibria still exist and the impact of more intense competition can be positive provided that unshrouding costs are not too high. For high levels of unshrouding cost we observe a non-monotonic relationship where unshrouding is likely for an intermediate market concentration, but less prevalent for very competitive and very concentrated markets.

## 6 Conclusion

This paper has revisited shrouding of add-on information in the framework of Gabaix and Laibson (2006), but has modified the unshrouding mechanism. The main conclusion of the paper is that more intense competition may shift industry behavior toward unshrouding. We have provided two arguments in favor of this. Firstly, unshrouding becomes an equilibrium for a larger parameter range. Secondly, in the parameter range where multiple equilibria exist, unshrouding becomes more favorable in terms of risk. From this we conclude that fostering market entry may be an effective tool to increase market performance, even in situations where initial consumer information is poor.

Introducing unshrouding costs qualifies our results somewhat. For small level of unshrouding costs, unshrouding still becomes more prevalent if the number of firms is increased. However, for higher unshrouding costs a non-monotonic relationship between the number of firms and unshrouding may be observed.

## A Appendix

### Derivation of Proposition 1

The proof follows the one in Gabaix and Laibson (2006). The existence of symmetric equilibrium base-good prices is ensured by Caplin and Nalebuff (1991).

Consumers form the following beliefs: If a firm shrouds, sophisticated consumers rationally anticipate high add-on prices ( $\bar{p}$ ) to arise which is the profit-maximizing

add-on price. Hence, a consumer chooses the outside option at cost  $e$ . If a firm unshrouds, a sophisticated consumer can observe the chosen add-on price. Myopic consumers do not form beliefs about add-on prices. Given these beliefs it is optimal for a firm to charge an add-on price of  $\bar{p}$  if it shrouds and choose price  $e$  if it unshrouds.

We now determine equilibrium shrouding decisions. Define  $\underline{\alpha} = \frac{e}{\bar{p}}$  and  $\bar{\alpha} = \frac{e}{\bar{p}\mu(n-1)}$ .

i) Suppose that  $\alpha \geq \underline{\alpha}$ . We show that all firms shrouding add-on prices is an equilibrium.

Suppose that all firms except firm  $i$  shroud the add-on and set an add-on price  $\hat{p} = \bar{p}$ . If firm  $i$  also decides to shroud, it optimally sets an add-on price  $\hat{p}_i = \bar{p}$ , leading to profits of

$$\begin{aligned}\Pi_s &= (1 - \alpha)D(-p_i - e + p^* + e)[p_i] + \alpha D(-p_i + p^*)[p_i + \bar{p}] \\ &= D(-p_i + p^*)[p_i + \alpha\bar{p}].\end{aligned}\tag{5}$$

The first term are profits from sophisticated consumers who only demand the base good and avoid paying for the add-on by incurring costly effort. Hence, firm  $i$  earns an amount  $p_i$  for each sophisticated consumer. The second term gives the income from myopic consumers who purchase both the base good as well as the add-on. From each of those consumers firm  $i$  receives  $(p_i + \bar{p})$ .

If instead firm  $i$  decides to unshroud the add-on, it optimally sets an add-on price of  $\hat{p}_i = e$  so that sophisticated consumers also buy the add-on. For any price above  $e$  sophisticated consumers would prefer the outside option at cost  $e$ . Firm  $i$ 's profits are then

$$\begin{aligned}\Pi_u &= [1 - \alpha\mu(1)]D(-p_i - e + p^* + e)[p_i + e] \\ &\quad + \alpha\mu(1)D(-p_i + p^*)[p_i + e] \\ &= D(-p_i + p^*)[p_i + e].\end{aligned}\tag{6}$$

With unshrouding, both myopic and sophisticated consumers buy the add-on from firm  $i$ . Hence, firm  $i$  earns  $(p_i + e)$  per consumer. As a consequence, the profits with unshrouding are independent of the shares of myopic and sophisticated consumers.

Comparing (5) and (6) reveals that shrouding leads to higher profits if  $\Pi_s \geq \Pi_u \Leftrightarrow \alpha \geq \frac{e}{\bar{p}} = \underline{\alpha}$ . Hence, if  $\alpha \geq \underline{\alpha}$  no firm has an incentive to deviate from shrouding the add-on and a symmetric equilibrium wherein all firms shroud exists.

Finally, let us derive the base-good price in a shrouding equilibrium. The first-order condition with respect to the base-good price  $p_i$  is given by  $(p_i + \alpha\bar{p})D'(-p_i + p^*) +$

$D(-p_i + p^*) = 0$ . Solving for the symmetric equilibrium price yields  $p^* = \frac{D(0)}{D'(0)} - \alpha\bar{p}$ . Firms earn profits of  $D(0)^2/D'(0)$ .

ii) Next, suppose that  $\alpha \leq \bar{\alpha}$ . We show that in this case an equilibrium exists where all firms unshroud.

Suppose that all firms except firm  $i$  unshroud the add-on and set an add-on price  $\hat{p}^* = e$ . If firm  $i$  also decides to unshroud the add-on, it optimally sets an add-on price of  $\hat{p}_i = e$ . Firm  $i$ 's profits are then

$$\begin{aligned}\Pi_u &= [1 - \alpha\mu(n)]D(-p_i - e + p^* + e)[p_i + e] \\ &+ \alpha\mu(n)D(-p_i + p^*)[p_i + e] \\ &= D(-p_i + p^*)[p_i + e].\end{aligned}\tag{7}$$

The first term are the profits from selling the base good and the add-on to sophisticated consumers and the second term from selling to the myopic consumers. Again, with unshrouding, overall profits are independent from the share of myopic and sophisticated consumers.

If instead firm  $i$  decides to shroud, it optimally sets an add-on price  $\hat{p}_i = \bar{p}$  to take full advantage of myopic consumers. This leads to profits of

$$\begin{aligned}\Pi_s &= [1 - \alpha\mu(n-1)]D(-p_i - e + p^* + e)[p_i] \\ &+ \alpha\mu(n-1)D(-p_i + p^*)[p_i + \bar{p}] \\ &= D(-p_i + p^*)[p_i + \bar{p}\alpha\mu(n-1)].\end{aligned}\tag{8}$$

Note that with  $n-1$  firms unshrouding and 1 firm shrouding, the number of myopic consumers is  $\alpha\mu(n-1)$  and the share of sophisticated consumers is then  $1 - \alpha\mu(n-1)$ . The first term of (8) is the income from selling to sophisticated consumers who only buy the base good. The second term of (8) is the income from myopic consumers buying both the base good and the add-on. Note that the profits from shrouding decrease when there is a larger number of unshrouding firms in the market. This is because the number of myopic consumers who would buy the expensive add-on becomes smaller with more firms unshrouding, that is,  $\alpha\mu(n-1)$  is decreasing in  $n$  and the incentive to deviate by shrouding become smaller.

Comparing (7) and (8) reveals that unshrouding leads to higher profits if  $\alpha \leq \bar{\alpha} = \bar{\alpha}$ . Hence, if  $\alpha \leq \bar{\alpha}$  no firm has an incentive to deviate from unshrouding add-on information and a symmetric equilibrium wherein all firms unshroud exists.

The equilibrium base-good price with all firms unshrouding can be derived by inspecting the first-order condition  $(p_i + e)D'(-p_i + p^*) + D(-p_i + p^*) = 0$ . The symmetric equilibrium price is then  $p^* = \frac{D(0)}{D'(0)} - e$  and profits amount to  $D(0)^2/D'(0)$ .



iii) Next, note that  $\underline{\alpha} < \bar{\alpha}$  because  $0 < \mu(n-1) < 1$ . Hence, we can distinguish three equilibrium regions:

- $\alpha > \bar{\alpha}$ : There is a unique symmetric equilibrium where all firms shroud add-on information.
- $\bar{\alpha} \geq \alpha \geq \underline{\alpha}$ : Both, a symmetric shrouding and an unshrouding equilibrium exists.
- $\alpha < \underline{\alpha}$ : There is a unique symmetric equilibrium where all firms unshroud add-on information.

iv) Note that asymmetric equilibria where some firms shroud and some firms unshroud cannot exist. We demonstrate this by contradiction. Suppose there is an equilibrium where  $0 < k < n$  firms unshroud and  $n - k > 0$  firms shroud. An unshrouding firm does not deviate to shrouding if  $D(-p_i + p^*)[p_i + e] \geq D(-p_i + p^*)[p_i + \alpha\mu(k-1)\bar{p}] \Leftrightarrow e \geq \alpha\mu(k-1)\bar{p}$  and a shrouding firm does not deviate if  $D(-p_i + p^*)[p_i + \alpha\mu(k)\bar{p}] \geq D(-p_i + p^*)[p_i + e] \Leftrightarrow \alpha\mu(k)\bar{p} \geq e$ . Together,  $\mu(k-1) \leq \frac{e}{\alpha\bar{p}} \leq \mu(k)$ . As  $\frac{\partial \mu}{\partial k} < 0$ , this condition cannot be satisfied, hence a contradiction, and an asymmetric equilibrium does not exist.

### Derivation of Proposition 3

i) The risk dominant equilibrium can be found by applying the tracing procedure by Harsanyi and Selten (1988).

Suppose that a player assigns a probability  $q$  to the event that all remaining players choose to shroud while the probability  $1-q$  is assigned to the event that all remaining players choose to unshroud.

Let  $\bar{q} = \frac{e - \alpha\bar{p}\mu(n-1)}{\alpha\bar{p}[1 - \mu(n-1)]}$  be the marginal belief such that a player with belief  $q$  is indifferent between shrouding and unshrouding. Hence, given a player's belief  $q$ , the best response is to shroud if  $q > \bar{q}$  and to unshroud if  $q < \bar{q}$ . Note that  $\frac{\partial \bar{q}}{\partial \alpha} < 0$  and  $\frac{\partial \bar{q}}{\partial n} > 0$ .

Harsanyi and Selten (1988) assume that prior beliefs  $q$  are uniformly distributed on  $[0, 1]$ . Thus, a given firm chooses to shroud with probability  $(1 - \bar{q})$  and to unshroud with probability  $\bar{q}$ . Given these priors, the expected benefit from shrouding is  $\alpha\bar{p}E[\mu(\bar{q}(n-1) - 1)]$  and the expected benefit from unshrouding is  $e$ . Comparison reveals that unshrouding is the risk dominant equilibrium if  $H = \alpha\bar{p}E[\mu(\bar{q}(n-1) - 1)] - e < 0$ . As  $\frac{\partial H}{\partial \alpha} > 0$ , there exists a critical  $\alpha^*$  such that shrouding is the risk dominant equilibrium if  $\alpha > \alpha^*$  and unshrouding is the risk dominant equilibrium if  $\alpha < \alpha^*$ .

Finally, by the implicit function theorem, it can be shown that

$$\frac{d\alpha^*}{dn} = -\frac{\frac{\partial H}{\partial n}}{\frac{\partial H}{\partial \alpha}} > 0. \quad (9)$$

Hence, it follows that the range of  $\alpha$  where unshrouding is the risk dominant equilibrium increases if  $n$  becomes larger.

ii) Kim (1996, p. 216) shows that an equilibrium  $H$  is selected by the global games approach if

$$\sum_{k=1}^n \frac{1}{n} [\pi_k^H - \pi_k^L] > 0, \quad (10)$$

where  $\pi_k^j$  denotes the payoff for a player choosing strategy  $H$  if the total number of players choosing that strategy is  $k$ . Applied to our game shrouding is the selected equilibrium strategy if

$$\sum_{k=1}^n \frac{1}{n} [\bar{p}\alpha\mu(n-k) - e] > 0, \quad (11)$$

which can be re-expressed as

$$\alpha > \frac{ne}{\bar{p} \sum_{k=1}^n \mu(n-k)} = \tilde{\alpha}(n). \quad (12)$$

Hence, if  $\alpha < \tilde{\alpha}(n)$  unshrouding is the selected equilibrium. As  $\tilde{\alpha}(n+1) > \tilde{\alpha}(n)$ , it follows that the parameter space where unshrouding is the selected equilibrium increases with  $n$ .

## Derivation of Proposition 4

Suppose that all firms unshroud the add-on and set an add-on price  $\hat{p}^* = e$ . Then, the equilibrium base-good price is equal to  $p^* = \frac{t}{n} - e$  and all firms would earn profits of  $\Pi = \frac{t}{n^2} - c$  which corresponds to the standard Salop profit less the fixed costs of unshrouding. We will show that is an equilibrium under the conditions provided in Proposition 4.

First, all firms unshrouding can only be an equilibrium if profits are nonnegative, that is,  $\frac{t}{n^2} - c \geq 0$ . Solving for  $c$  gives condition ii) in Proposition 4. Second, no firm may deviate to shrouding and increase its profits. Let  $\hat{\alpha} = \frac{ne + 2\sqrt{t(t-cn^2)} - 2t}{n\bar{p}\mu(n-1)}$  and suppose firm  $i$  deviates. Then, this firm would sell the add-on only to myopic consumers and earn  $(\frac{1}{n} + \frac{p^* - p_i}{t})(p_i + \alpha\mu(n-1)\bar{s})$ . The optimal base-good price in case of shrouding would be  $p = \frac{t}{n} \frac{1}{2}(e + \alpha\mu(n-1)\bar{s})$  leading to profits of  $\frac{(2t\alpha\mu(n-1)\bar{s} - en)^2}{4tn^2}$ . Firm  $i$  has no

incentive to deviate if  $\frac{(2t\alpha\mu(n-1)\bar{s}-en)^2}{4tn^2} \leq \frac{t}{n^2} - c$  which is satisfied if  $\alpha \leq \hat{\alpha}$ . This gives condition i) in Proposition 4.

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